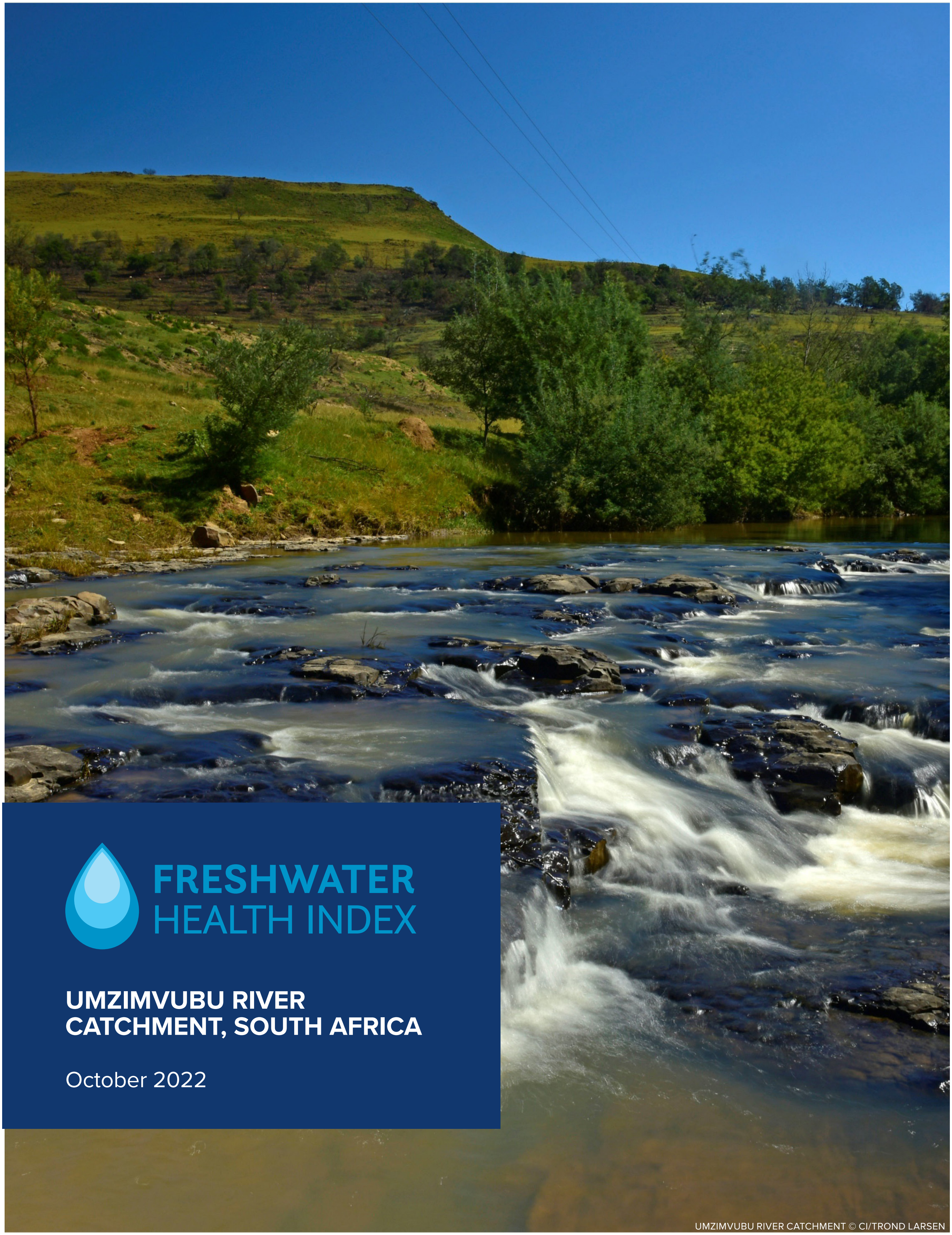

FRESHWATER HEALTH INDEX

UMZIMVUBU RIVER CATCHMENT, SOUTH AFRICA

October 2022

UMZIMVUBU RIVER CATCHMENT © CI/TROND LARSEN

ACKNOWLEDGMENTS

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We would also like to acknowledge the contributions of our FHI team (http://www.freshwaterhealthindex.org/project-staff), which provided the technical guidance and support throughout the Freshwater Health Index application.

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TABLE OF CONTENTS

UMZIMVUBU RIVER CATCHMENT

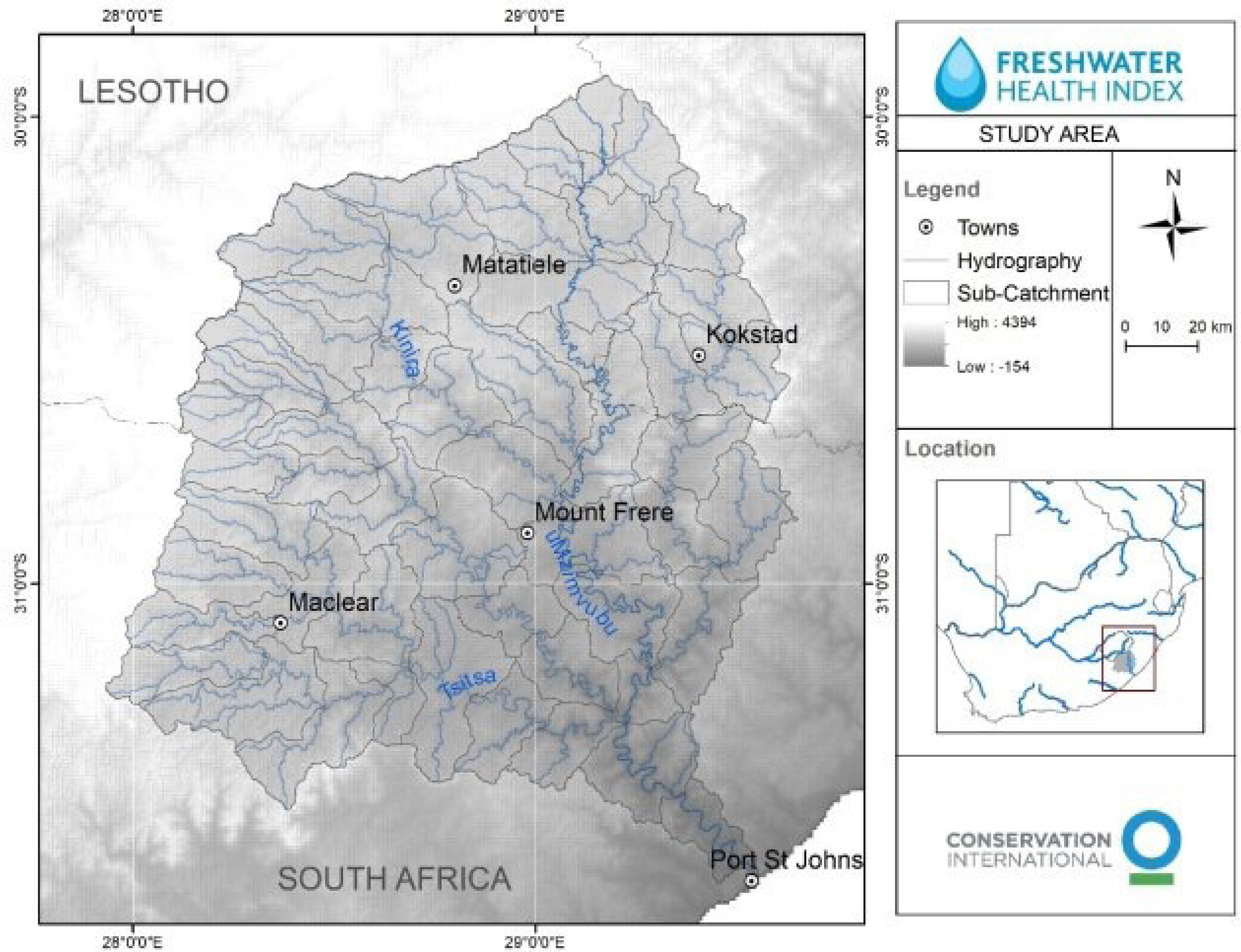

Figure 1. Map of the assessment area.

EXECUTIVE SUMMARY

UMZIMVUBU RIVER CATCHMENT

The Umzimvubu Catchment is an important freshwater system in South Africa. The catchment includes two Strategic Water Source Areas (SWSA) that contribute 50% of mean annual runoff from just 10% of the catchment area (Nel et al. 2013). The Umzimvubu is considered one of the least modified freshwater systems that remain in the country. This catchment is also rich in biodiversity, supporting more than 2,000 plant and animal species unique to the landscape.

The Umzimvubu Catchment falls in one of the former homeland areas known as the Transkei, and this has shaped the current challenges of poverty and environmental degradation in this area. The catchment supplies water for more than 2 million people, predominantly in rural and peri-urban settlements. Thus, there is a great need for water advancements that fulfill the growing demand for water (e.g., domestic use, agriculture) to improve the quality of life for the people living in the landscape.

Considering these factors, the Freshwater Health Index (FHI) was applied in the Umzimvubu Catchment to evaluate its overall health in three components: Ecosystem Vitality, Ecosystem Services and Governance and Stakeholders. Importantly, the assessment process included stakeholder meetings in order to obtain some of the data necessary for the FHI calculations and to validate results. Stakeholder engagement also provided additional understanding of how the FHI can contribute to resource management as managers increasingly understand synergies between the biophysical system, provision of benefits and the water governance system in place.

The FHI can be used to monitor and measure the achievement of collaborative efforts adopted within the Umzimvubu Catchment, through the Umzimvubu Catchment Partnership (UCP). The UCP is a platform where various stakeholders have committed to foster collective action to implement a catchment management strategy and restoration plan for the benefit of people and nature. The FHI's usefulness stems from its ability to identify opportunities for conservation, address underlying issues rooted in governance and provide clarity in communicating complex ecological phenomenon, thus contributing to the pursuit of achieving the goals of the UCP.

The sustainability of water resource management is based on the joint consideration of various dimensions: social, environmental, economic, cultural and political. The latter being critical to ensure the proper involvement and development of institutions and the legal and regulatory frameworks. These dimensions of sustainability must be integrated throughout the water resource management process – from the planning stage, through the systematic assessment of resources, to the final stage of assessing management impacts. Thus, the FHI provides a neutral platform for sharing knowledge about the state of the Umzimvubu Catchment, evaluating the biophysical ('Ecosystem Vitality', 'Ecosystem Services') and social components ('Governance & Stakeholders') of the catchment.

The FHI can also contribute to the generation of specific results for the UCP partners who are involved in initiatives that address development of sustainable natural resources management and maintenance that supports functioning ecosystems, social cohesion, and livelihoods. This can be attained through enhancing the flow of services from the landscape to the people. More specifically, the FHI is a tool that provides a "State of the Catchment" report that can be used to inform the initiatives and approaches of stakeholders working in this landscape.

KEY RESULTS

- The Ecosystem Vitality component obtained a score of 47, suggesting that the ecosystem itself is showing signs of degradation, which may impact the delivery of services in the future. Of the indicators evaluated, Water Quality and Catchment Condition received the highest scores (69 and 67, respectively). Biodiversity received a score of 36, and Water Quantity obtained the lowest scores (30) under this component. The low score for Biodiversity is driven by a high number of critically endangered species, as well as the pervasive presence of invasive alien plants, which impact not only riparian habitat but also water flow. Water Quantity rated poorly because of an exceptionally low score for the Deviation from Natural Flow sub-indicator (14); despite its reputation as being one of the least modified catchments in the country, the combination of invasive alien plants and thousands of small dams to catch runoff have dramatically altered the flow regime, in terms of when water flows and how much reaches the sea.

- The Ecosystem Services component received the lowest component score (32), indicating that the Umzimvubu basin is not adequately meeting the needs of the people who depend on it. There are already indications that supply for some services is being compromised. The priorities uncovered by the FHI are for the following services: Water Supply Reliability (29), Sediment Regulation (18) and Conservation of Cultural Heritage (11). In addition to these priorities, catchment managers should consider that provisioning services were considered the most relevant for the stakeholders consulted, as they received a high overall weight (nearly half of the total for all three Ecosystem Service indicators, with Water Supply Reliability receiving the highest overall weight). In other words, the integrated and sustainable management of the catchment depends not only on making decisions to ensure the adequate supply of services, but also on considering and balancing stakeholders' collective interests.

- The Governance and Stakeholders component received a score of 51, the highest of the three components though still an area of concern. The lowest scoring indicator was Enabling Environment (44), with particularly low scores for the Financial Capacity (30) and Technical Capacity (38) sub-indicators. The Stakeholder Engagement and Vision and Adaptive Governance indicators both scored higher (57 and 58, respectively), which suggests that efforts such as the establishment of the UCP may already be having a positive impact. Of note, the sub-indicator Engagement in Decision-making processes received one of the highest overall scores (60). But there is still a gap in terms of overall implementation and execution, as measured by the Effectiveness indicator (49). Here, comparatively higher scores for Distribution of Benefits (55) and Water-Related Conflict (53) are offset by a low score for Enforcement (42), signaling a need to consider how existing policies and laws around land and water use can be better upheld.

The results of the baseline evaluation of the Freshwater Health Index appear to be in line with the reality on the ground for the Umzimvubu Catchment. The higher score of Ecosystem Vitality in relation to the Ecosystem Services component is an interesting result, as the environment usually shows signs of degradation in its biophysical factors before exhibiting a reduction in the provision of services. But in this case, two of the lowest scoring sub-indicators are due to a lack of supporting infrastructure – piped water for households and formal protections for lands and waters with cultural significance.

It is also important to highlight that management priorities should be aligned with the common interests of stakeholders. In the case of the Umzimvubu Catchment, collectively, the most important ecosystem service is water supply for domestic and agricultural use. Thus, integrated management of the catchment should balance the provision of the most relevant services for stakeholders and areas that need attention from managers (those with lower scores).

CONCLUSIONS & NEXT STEPS

The Umzimvubu Catchment FHI assessment demonstrated that the ecosystem service delivery is under stress, mainly due to poor water supply reliability and cultural service delivery. These results show the need for enhancing the supply of benefits that people in the catchment need and strengthening the institutional decision-making for water resources management. One of the factors that the results confront is the current and future role of spring rehabilitation and protection work to alleviate the identified water access challenges in the catchment.

This assessment provides a process to engage more deeply with stakeholders' practices and their commitment to improved water resources management. It provides a broad understanding of the status quo of freshwater systems that managers and decision-makers can use to further investigate some of the challenges identified in this assessment. This process can be done through extensive modeling, mapping and ground-truthing of these variables to further justify and inform the development of a shared vision for the catchment. The shared vision should reflect the findings from this report, address the data gaps highlighted and suggest plans to improve poor-performing indicators. This plan should be spatially explicit and align with the work of the stakeholders in the Umzimvubu Catchment Partnership.

The index provides a guide for future investment in freshwater systems in the catchment and has the potential to inform future priorities. These priorities should be captured in the shared vision and catchment plan and done in consultation with all stakeholders.

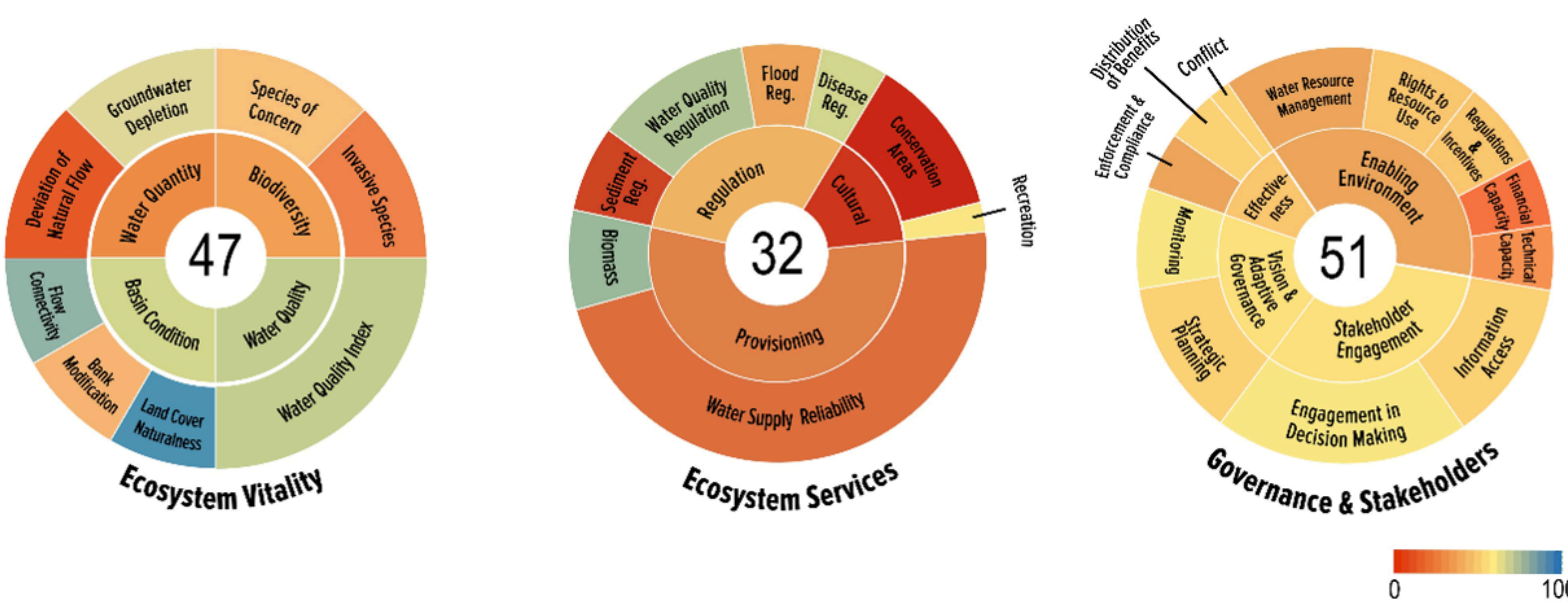

Figure 2. Baseline scores of the Freshwater Health Index for the Umzimvubu catchment.


UMZIMVUBU UPPER CATCHMENT © CI/CAROLINE ROSE

1. INTRODUCTION

The Umzimvubu catchment and river system lies along the northern boundary of the Eastern Cape Province and extends for more than 200 km from its source in the Maloti-Drakensberg watershed on the Lesotho escarpment to the coastal mangroves of Port St. Johns, where it joins the Indian Ocean. This catchment is characterised by a complex mix of grasslands, forest, thicket and dune vegetation, which are habitats for a diverse community of plant and animal species. This area holds four Key Biodiversity Area classes within the Maputaland-Pondoland-Albany Hotspot, and these priority areas are of global importance for terrestrial and aquatic species.

The Umzimvubu River System has been prioritised nationally as being one of the least transformed freshwater systems. Still, it is classified as vulnerable as a result of rapid rates of degradation in the watershed. There is, for example, a growing concern about rapid invasion of alien plants (mainly Acacia mearnsii and Acacia dealbata), uncontrolled burning, overgrazing, inappropriate infrastructure location and land degradation, which could irreparably alter the amount and quality of the water in this catchment.

This Umzimvubu catchment covers 2 million hectares and is comprised of almost 70% communal land. It falls into 10 local municipalities, that fall under the Alfred Nzo, OR Tambo and Greater Kokstad district municipalities. The catchment primarily sits within the Eastern Cape Province, with a small portion in the KwaZulu Natal Province. The communal land tenure is generally complex and multifaceted, as this land is under the custodianship of the Department of Rural Development and Land Reform (DRDLR) on behalf of communities. The local management of communal lands is under the traditional authority of the chiefs and headmen in the villages.

Although the scenic view of the Umzimvubu Catchment shows largely intact landscapes and naturally functioning ecosystems, the intensification of human activities in the catchment is beginning to put pressure on its ecosystem. The Umzimvubu Catchment Partnership (UCP) supports the restoration and maintenance of these systems. This is done through collaborative efforts to protect and conserve water resources in an equitable manner. The UCP provides a platform for strong collaboration and demonstration of varying initiatives in the catchment to encourage alignment and expansion of the work in the next two decades. The partnership is heavily focused on working with stakeholders, state and non-state, and developing the freshwater system sustainably. The UCP follows an approach to restoring catchment integrity, improving livelihoods and building resilient ecosystems through collaborative governance. This is mirrored by the FHI goals, that seek to encourage an integrated and participatory approach toward freshwater management.

The FHI was applied in this catchment to help stakeholders assess conditions and improve planning for the future through understanding key priorities for stakeholders and measuring overall health in three dimensions: Ecosystem Vitality, Ecosystem Services, and Governance and Stakeholders.

Table 1. Results for Freshwater Health Index Indicators

Indicators	Score	SUBINDICATORS	Score
ECOSYSTEM VITALITY	47		
Water Quantity	30	Deviation of Natural Flow	14
		Groundwater Storage Depletion	65
Water Quality	69	Water Quality Index	69
Catchment Condition	67	Bank Modification	88
		Flow Connectivity	44
		Land Cover Naturalness	77
Biodiversity	36	Species of Concern	48
		Invasive Species	27
ECOSYSTEM SERVICES	32		
Provisioning	33	Water Supply Reliability	29
		Biomass for Consumption	76
Regulation and Support	47	Sediment Regulation	18
		Water Quality Regulation	70
		Regulation of Diseases	67
		Flood Regulation	43
Cultural	14	Conservation and Cultural Heritage	11
		Recreation	61
GOVERNANCE & STAKEHOLDERS	51		
Enabling Environment	44	Water Resource Management	46
		Rights to Resource Use	51
		Incentives and Regulations	49
		Technical Capacity	38
		Financial Capacity	30
Stakeholder Engagement	57	Information Access	54
		Engagement in Decision-Making Processes	60
Effectiveness	49	Enforcement and Compliance	42
		Distribution of Benefits from Ecosystem Services	55
		Water-Related Conflict	53
Vision and Adaptive Governance	58	Monitoring Mechanisms	61
		Comprehensive Planning and Adaptive Management	56

2. ECOSYSTEM VITALITY: INDICATOR AND SUB-INDICATOR RESULTS

The Ecosystem Vitality component of the Freshwater Health Index measures the integrity and functioning of ecosystems (streams, rivers, wetlands and forests) within the catchment. Healthy ecosystems are essential to provide clean water, fish, flood protection and a variety of other benefits that people depend on. The four main indicators within the Ecosystem Vitality component measure are: Water Quantity, Water Quality, Catchment Condition and Biodiversity. They are presented at the sub-catchment level, where possible, to illustrate how the scores of the sub-indicators vary spatially.

Combining the four main indicators, **the Umzimvubu Catchment received a score of 47 for Ecosystem Vitality**. This suggests that ecosystem health requires attention, though it is worth noting that some indicators have better scores than others (Table 1). In addition, there are notable data deficiencies that need to be addressed. It is important to highlight that, unlike the other two components of the FHI, the Ecosystem Vitality component indicators and sub-indicators are not weighted by stakeholders before they are aggregated, because they represent characteristics inherent to the environment or ecosystem, whereas the other indicators are more readily influenced by stakeholder preferences.

2.1 Water Quantity

The Water Quantity indicator measures the amount and flow of water within the catchment, including surface water and groundwater. Aquatic ecosystems depend on seasonal water patterns in the catchment, and, in many places, people also rely on seasonal fluctuations. The pattern of these natural fluctuations can be altered by the construction of dams to regulate periods of flooding and droughts. That is, the natural condition is sacrificed to meet human needs. However, these trade-offs can have negative consequences for aquatic biodiversity and for human communities that rely on a natural flow pattern, such as for fishing. The Water Quantity indicator is measured through two sub-indicators: Deviation of Natural Flow and Groundwater Storage Depletion. **The Umzimvubu Catchment obtained a score of 30 for the Water Quantity indicator**; this indicator is considered critical and requires improvement.

2.1.1 Deviation from Natural Flow Regime

The Deviation of Natural Flow sub-indicator measures the degree to which the flow pattern has been altered by land-use changes. This indicator measures the degree to which current flows have changed in relation to historic natural flows. The presence of reservoirs, agricultural activities, deforestation, and urbanization can affect the regime and volume of surface flows, which in turn influence the general functioning of rivers and streams – and, consequently, the ecosystem services provided to people. For example, drastic changes in the landcover can be a major driver of change in the present observed flow. Landcover alterations from poor land management, invasion of alien species and land degradation can substantially change the flow. **The Deviation of Natural Flow received a score of 14 for the Umzimvubu Catchment, suggesting, with the maximum modification of flow and far less water reaching downstream than would be expected under baseline natural conditions.**

2.1.2 Groundwater Storage Depletion

The Groundwater Storage Depletion sub-indicator measures changes in the availability of water stored in underground aquifers. Underground water resources represent a significant portion of the water resources available for human use and, usually, their reserves are much higher than surface water availability. Increasingly, groundwater extraction is becoming important to meet the demands of rural communities in the Umzimvubu Catchment, although knowledge about the number of wells/springs and their volumetric capacities is lacking. In general, the data and level of knowledge about the basic characteristics of groundwater in the catchment is quite limited. The Strategic Water Source Areas for groundwater (SWSA-gw) that have been delineated as part of a Water Research Commission (WRC) project (K5/2431) reflect areas that have high groundwater recharge. These are areas which have high groundwater availability and thus are of national importance. However, this dataset does not reflect the groundwater storage stress or depletion. The Groundwater Resource Assessments II study done in 2004, aimed to provide an approach to quantifying groundwater resources and areas where the underlying groundwater system is clearly stressed. **The Groundwater Storage Depletion sub-indicator in the Umzimvubu Catchment received a score of 65, indicating reasonably good health** (Figure 3). Stakeholders in the catchment identified the need to invest in groundwater research to understand the locations and trends in groundwater storage fully as this has implications for provisioning of water through springs and boreholes in the catchment.

2.2 Water Quality

Water Quality refers specifically to the physiochemical characteristics (e.g., concentrations of substances) required to maintain aquatic biodiversity in the most natural state possible. Pollution by sewage or nappies disposal, for example, can directly damage aquatic life and alter the ecological balance by triggering the proliferation of harmful algae. This indicator consists of a single sub-indicator, the Water Quality Index, that comprises multiple quality parameters.

2.2.1 Water Quality Index

The Water Quality Index measures how much the physiochemical characteristics (e.g., concentrations of water quality parameters) differ from thresholds necessary to maintain aquatic biodiversity. **The Water Quality Index in the Umzimvubu Catchment received an aggregate score of 69, indicating reasonably good health.**

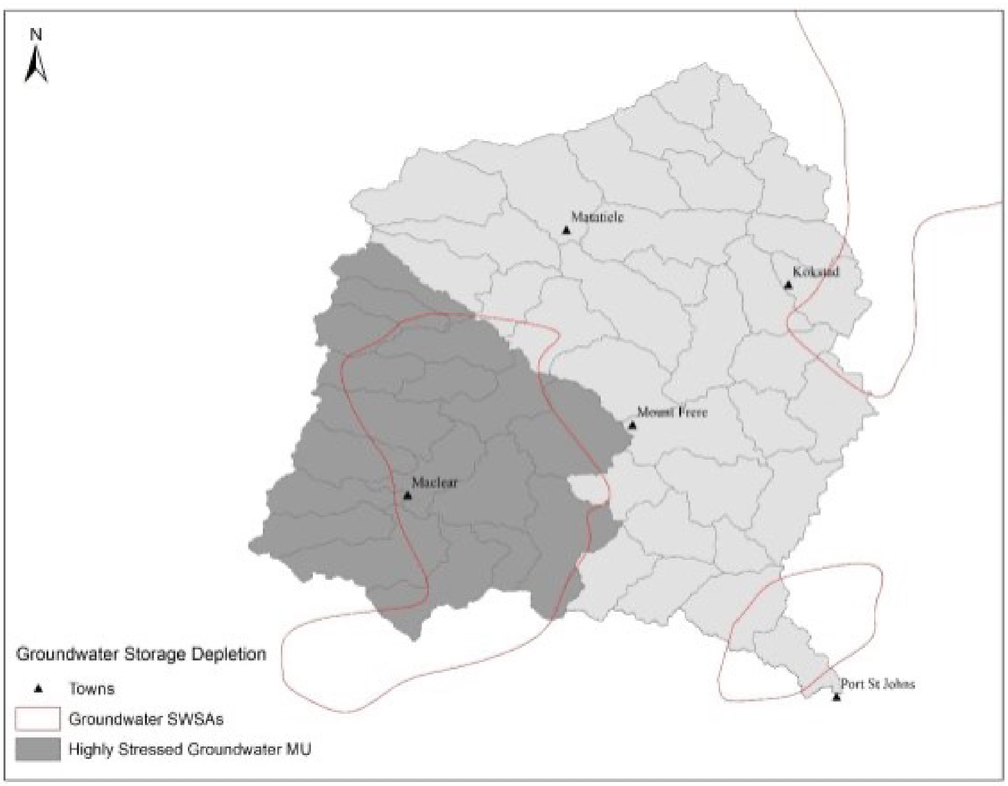

Figure 3: Results for the groundwater storage depletion indicator.

Separately, the Kinira sub-catchment (T3H002Q01 station) scored 77 and the Mooi sub-catchment near Maclear (T3H009Q01 station) received a score of 76, that is, the water quality measured at the two stations in the upper catchment reflects relatively good health. In the case of middle and lower Umzimvubu Catchment, the most problematic stations (with a score lower than 70) were: Umzimvubu River at the Mzinto confluence (T3H005Q01 station) (68), Umzimvubu at the Kromdraai confluence (T3H008Q01 station) (65), Mzintlava sub-catchment (T3H004Q01) (62), and Tsitsa sub-catchment (T3H003Q01) (61). The results for these four stations reflect a deviation from the acceptable limit for concentrations, primarily for turbidity and E.coli coliforms, which were the lower performing parameters. The low score for the Mzintlava sub-catchment at Kokstad (T3H004Q01 station) may be associated with the irrigation systems from the dairy farming impacting the increased sediment and fertilizer concentrations in the river, and the Mount Ayliff wastewater treatment works (DWS, 2017). The low score for the Tsitsa sub-catchment (T3H003Q01) may be a result of the wastewater treatment works in Tsolo, which is considered a critical risk. This may lead to increased nutrient in the river (DWS, 2017).

There is a need for more water quality monitoring in the catchment to obtain a comprehensive picture of the state of water quality, especially the streams in the upper catchment. This sub-indicator included water quality data from 2017 and 2019, measuring several parameters, although some of the datasets included very sparse data. There is a need for more extensive data collection. In general, it is noted that the water quality of the catchment could be better evaluated if there were an expansion of the monitoring network to allow the provision of a status for the entire Umzimvubu Catchment area. At present, monitoring is only at 6 stations, as illustrated in Figure 4.

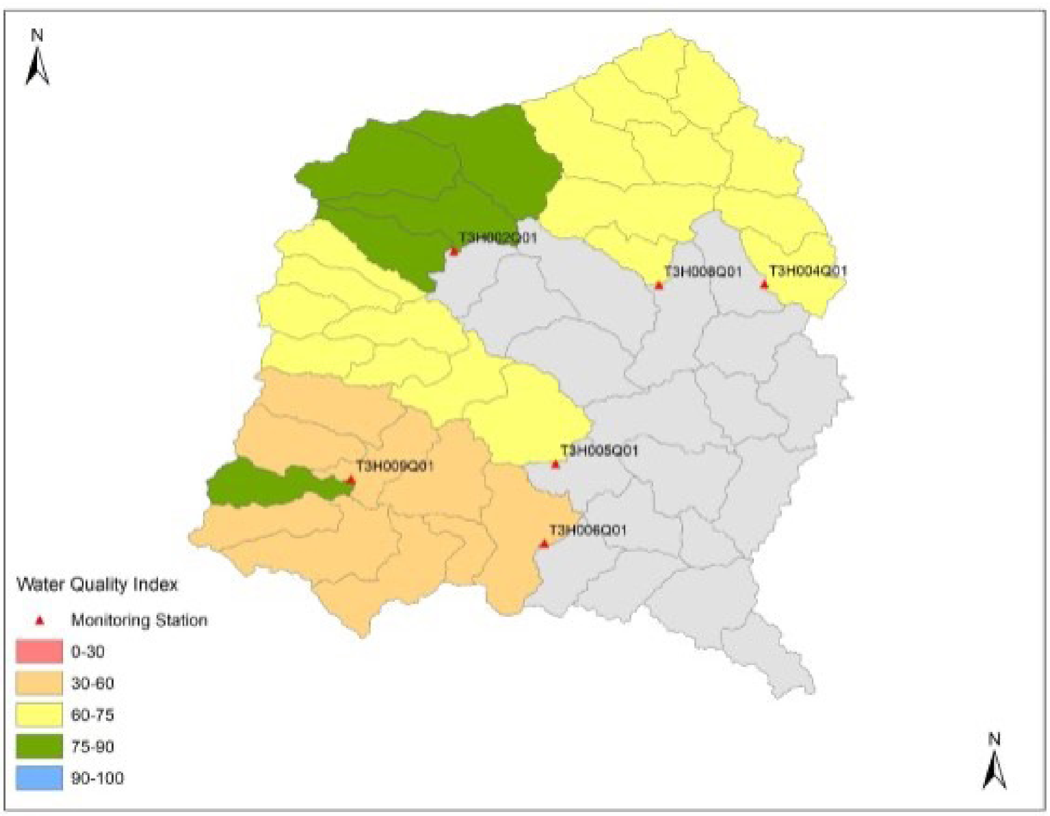

Figure 4: Results of the Water Quality Index.

2.3 **Catchment Condition**

The Catchment Condition indicator measures the extent of physical modifications, both of land cover (e.g., forests converted to agriculture) and of streams and rivers (e.g., the construction of dams or the expansion of canals), which can affect the flow and quality of water, as well as habitat for aquatic life. The Catchment Condition indicator is measured through three sub-indicators: Bank Modification, Flow Connectivity and Land Cover Naturalness. **When these three sub-indicators were combined, the Umzimvubu Catchment received a score of 67, indicating reasonably good health.**

2.3.1 **Bank Modification**

The Bank Modification sub-indicator assesses the lateral connectivity of flows responsible for the exchange of material between rivers and floodplains. Lateral connectivity determines how surface water flows reach rivers and streams, and how materials (e.g., nutrients and sediments) are exchanged between terrestrial and aquatic systems. Changes in this pattern, whether by channeling or flooding through dams, affect the establishment of native riparian vegetation and wildlife (including spawning fish and waterbirds), the biogeochemistry of streams, as well as the extent of floodplains. **The Bank Modification sub-indicator received a score of 88, indicating minimal changes to the banks of rivers and streams being observed in the Umzimvubu Catchment.**

This score is consistent with the reasonably low degree of land cover change in the catchment. Inspection by high-definition satellite images confirmed that the degree of bank modification can still be considered low, as there are few instances of human-made channels. In general, it is noted that the changes to banks occurred mainly in the upper and middle catchment where there is substantial gully erosion (Figure 5). The main regions with bank modifications were the areas below the Maclear Town, the tributaries of the Inxu and Thina Rivers, as well as in the upper parts of the catchment, in the tributaries of the Kinira River.

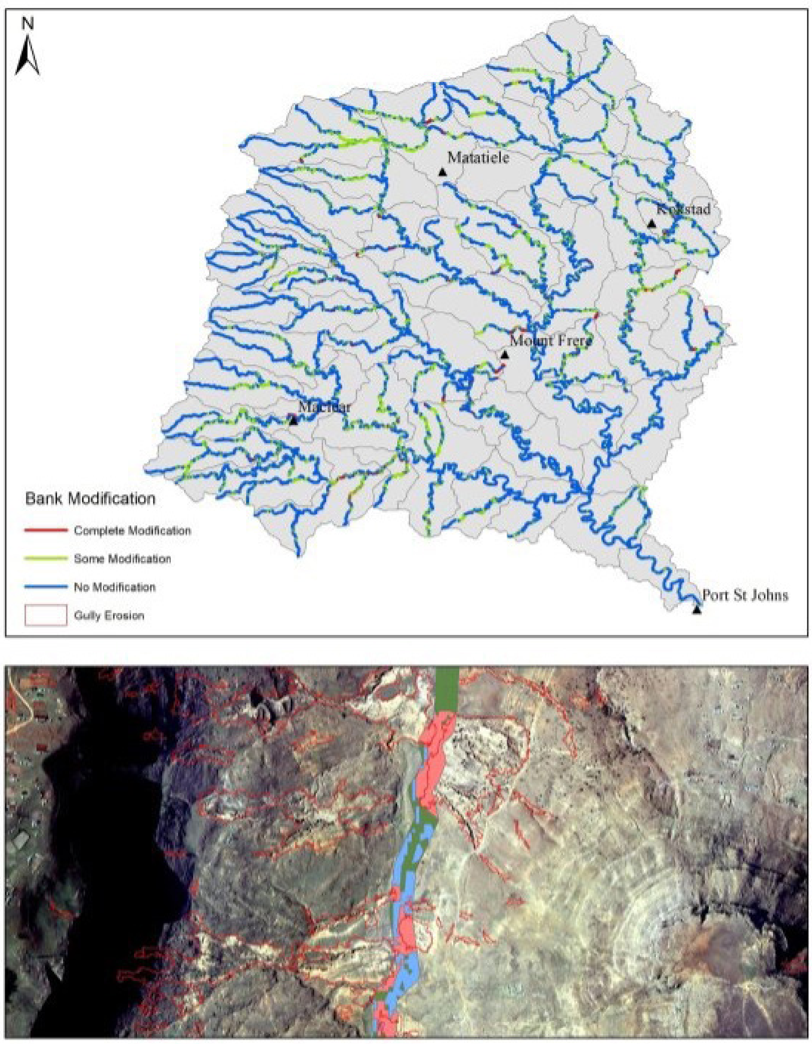

Figure 5: Bank Modification in the Umzimvubu Catchment.

2.3.2 **Flow Connectivity**

The Flow Connectivity sub-indicator measures drainage network fragmentation and is particularly important for the movement of aquatic life, such as fish, but also affects the natural flow of materials. The connectivity of flows can be altered by natural obstructions, such as waterfalls, or artificial obstructions such as engineering structures (e.g., dams and weirs). Reduced connectivity can negatively impact fish migration and reproduction and can prevent sediments and other nutrients from naturally flowing downstream. In this case, the Port St John's Coast depends on this natural pattern of material flow. **The Umzimvubu Catchment received a score of 44 for this sub-indicator, indicating a high fragmentation of the freshwater system.** The Umzimvubu Catchment does not have large dams; however, data from the Department of Water and Sanitation shows that there is a dense network of small to medium dams in this catchment. A total of 1,329 dams were identified in the catchment; most of these are designed to catch runoff but 76 dams are located in perennial streams (Figure 6). Additionally, 16 weirs (functional and non-functional) are located within streams and are considered obstructions to the river network. The dams are concentrated north-east of the catchment, around Kokstad, evidently because of the extensive agricultural farms in this area.

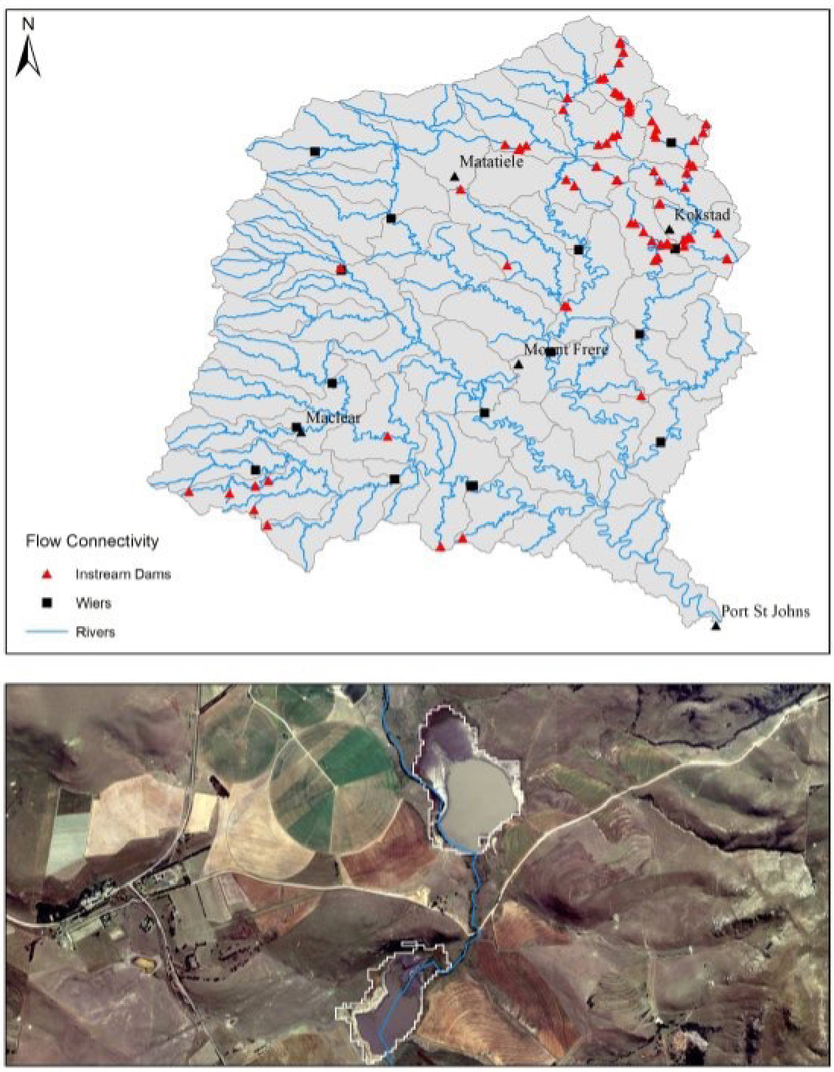

Figure 6: Fragmentation of river network in the Umzimvubu Catchment caused by instream dams and weirs.


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2.3.3 **Land Cover Naturalness**

The Land Cover Naturalness (LCN) sub-indicator measures how much land cover in the catchment has been modified by human activities. Forests and wetlands regulate the flow and quality of water, but when degraded or converted into pastures, agricultural areas or urban areas, the ecosystem loses its ability to regulate the water cycle. **The Umzimvubu Catchment received a score of 77, indicating that the natural vegetative cover has been only moderately modified so far.** Throughout the catchment, the natural and semi-natural land is maintained, although there are areas where the land cover has been transformed or culturally assisted, i.e., modified in some way by humans. This is characterized by seasonal or permanent vegetation cover with atypical species, and this is in line with the invasive alien plants distribution in the biodiversity indicator. The “completely artificial” areas are mostly characterized by barren land and gully and rill erosion. It is important to highlight that this sub-indicator is one of the most important drivers of change in other Ecosystem Vitality sub-indicators (Groundwater Depletion, Water Quality Index, Bank Modification and Species of Concern).

2.4 **Biodiversity**

Biodiversity refers to the status and trends of populations of animal and plant species that live directly in or near watercourses. Data on reductions in native species or increases in invasive species are used as indicators of ecosystem degradation. In addition, aquatic and riparian biodiversity are often positively associated with fishing and cultural services such as recreation. The Biodiversity indicator is divided into two sub-indicators: Species of Concern, which focuses on endangered, threatened or vulnerable species, and Invasive Species. **When these two sub-indicators were combined, the Umzimvubu Catchment received a Biodiversity score of 36, suggesting critical health.** This sub indicator represents only the proportion of threatened and invasive species in relation to the total, and *data on species populations over time are necessary* to improve the evaluation of the trends of biodiversity.

Figure 7: Images of the four critically endangered species in the catchment: (a) Amatola toad, (b) Hogsback dainty frog, (c) Maloti minnow and (d) Eastern Cape redfin.

2.4.1 **Species of Concern**

The Species of Concern sub-indicator measures how much of the native aquatic and riparian species are threatened. The decrease in species diversity is a warning sign of the deterioration of the ecosystem and may also correspond to declines in benefits for people, such as fishing. **The Species of Concern sub-indicator received a score of 48, indicating critical state for the biodiversity of the Umzimvubu Catchment.** That is, there are fewer freshwater species that were identified and assessed in the catchment, and almost 22% of those species are considered threatened in relation to the total number of evaluated species. This considers the most problematic classes (critically endangered, endangered, and vulnerable).

The catchment has four recorded critically endangered species: *Vandijkophrynus amatolicus* (Amatola toad)-which is endemic to the Eastern Cape province, *Tomichia tristis* – a small freshwater or brackish snail, *Tomichia cawstoni*- freshwater snail typically found in the Kokstad area in South Africa and *Pseudobarbus senticeps*- fish species that inhabits the mountainous streams with clear to peat tainted water. In addition to these species is the *Cacosternum thorini* (Hogsback dainty frog), *Pseudobarbus afer* (Eastern cape redfin fish) and *Pseudobarbus quathlambae* (Maloti minnow) which are all endangered and endemic to this region (Figure 7). These populations are becoming rare due to the altering of their habitats and the impact of invasive species such as the exotic bass species and *Labeobarbus aeneus* (smallmouth yellow fish). Thus, this sub-indicator is closely related to the sub-indicators in the **Condition of the Drainage Catchment** indicator (Bank Modification, Flow Connectivity, Land Cover Naturalness).

2.4.2 **Invasive & Nuisance Species**

The Invasive Species sub-indicator specifically measures the presence of exotic species introduced into the ecosystem, both intentionally and accidentally, that can compete or that impose a threat to native species. Increasing numbers and populations of exotic species can put pressure on native species, degrade ecosystems and negatively impact the economy and human health. **The Umzimvubu Catchment received a score of 27.** This value is based on the prevalence of invasive alien plants, mainly *Acacia dealbata*, which is a major driver of change in the Catchment (Figure 8).

The result shows that 10% of the total area of the catchment is invaded by this woody species, with certain sub-catchments exceeding 20% of their area being invaded. This is a potentially significant problem, as invasions have been estimated to result in >5% reductions in mean annual runoff in the region (Le Maitre et al., 2020). While the invasive species are not as prevalent in the downstream areas of the catchment, these areas still may be receiving impacts from the upstream as their presence has a substantial impact on biodiversity and water resources. The tool developed for the UCP, the *Water Calculator*, can be used to further understand the impact of these woody invasive alien plants on the catchment's water resources.

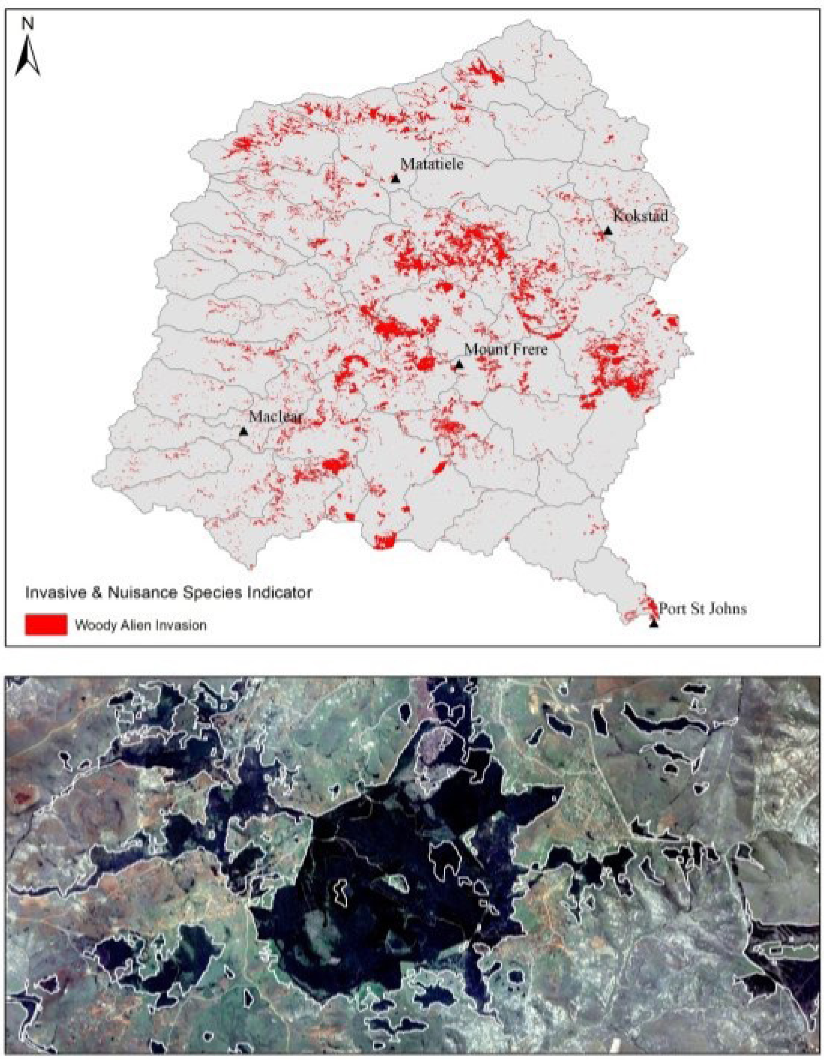

Figure 8: Invasive woody alien plants distribution in the catchment.


MVENYANE RIVER IN THE UMZIMVUBU CATCHMENT © CI/CAROLINE ROSE

3. ECOSYSTEM SERVICES: INDICATOR AND SUB-INDICATOR RESULTS

The second component of the Freshwater Health Index, Ecosystem Services, measures water-related benefits, including, for example, the supply of drinking water, sediment regulation and protection against floods. These benefits, often delivered in place of or as a complement to infrastructure, allow people to connect to the natural ecosystems on which they depend. Ecosystem Services are commonly classified according to how people experience them, and this is reflected in the three main indicators within this component: Provisioning (goods/services extracted from the ecosystem), Regulation and Support ("background" processes that occur in ecosystems, in other words, the functioning of ecosystems) and Cultural (experiences that people obtain from ecosystems).

Combining the three main indicators of Ecosystem Services, the Umzimvubu Catchment received a total score of 32. This suggests that the catchment needs immediate and specific attention in order for it to meet people's welfare needs. It is important to note that the final score for this indicator weights each sub-indicator and indicator differently, i.e., according to the relative importance given by stakeholders to each of the indicators and sub-indicators. Weighting revealed a preference for Provision Services (55%) in relation to Regulatory and Support services (30%) and Cultural (15%). For ecosystem service sub-indicators associated with Provisioning and Regulation and Support, scores are calculated based on spatial, temporal and magnitude factors, further explained in Appendix 1.

3.1 Provisioning

Provisioning services refer to the physical benefits, mainly water and fish, that people get from aquatic ecosystems. These benefits provided by aquatic ecosystems are essential elements for economic development and are essential for food security and water supply security. The Provisioning Services indicator has two sub-indicators: Water Supply Reliability and Biomass for Consumption. **The Provisioning Services indicator obtained a score of 34, indicating that the catchment is significantly underperforming in this area.** Stakeholders assigned a much higher weight (84%) for the Water Supply Reliability sub-indicator compared to the Biomass sub-indicator (16%), which indicates the higher importance they place on a secure water supply to meet various needs.

3.1.1 **Water Supply Reliability Relative to Demand**

The Water Supply Reliability sub-indicator measures the catchment's current capacity to meet water demand from various sectors throughout the catchment area. It considers seasonal variability, minimum amounts of water for ecological maintenance, known as environmental flows, as well as the distribution of water access infrastructure (piped water). A decrease in water supply reliability corresponds to increased water insecurity, ecological degradation, or unsustainable water consumption. **In the Umzimvubu catchment, Water Supply Reliability received a score of 29, indicating that there are significant challenges in meeting demand for water for human use, particularly in the downstream areas.** It should be noted that only data related to household use was analyzed for this calculation. Agricultural use was not taken into account. It is interesting to note that the outlier is the sub-catchment of Greater Kokstad, which had a significantly higher score for this indicator, as seen on the map below (Figure 9).

3.1.2 **Biomass for Consumption**

The Biomass for Consumption sub-indicator evaluates the amount of biomass (aquatic biota) that is used or acquired for consumption. **The Biomass for Consumption sub-indicator obtained a score of 76, which is a good score.** In the absence of data available on the consumption of fish harvested in the Umzimvubu Catchment, stakeholder surveys were used to analyze this indicator. Medicinal plants were one of the key biomasses harvested, followed by fish and the harvesting of thatch grass (iingca). It was also noted that some of this biomass harvested was to support livelihoods of people. There is the need for additional methods to understand biomass dependency in the catchment so that these resources can be managed sustainably.

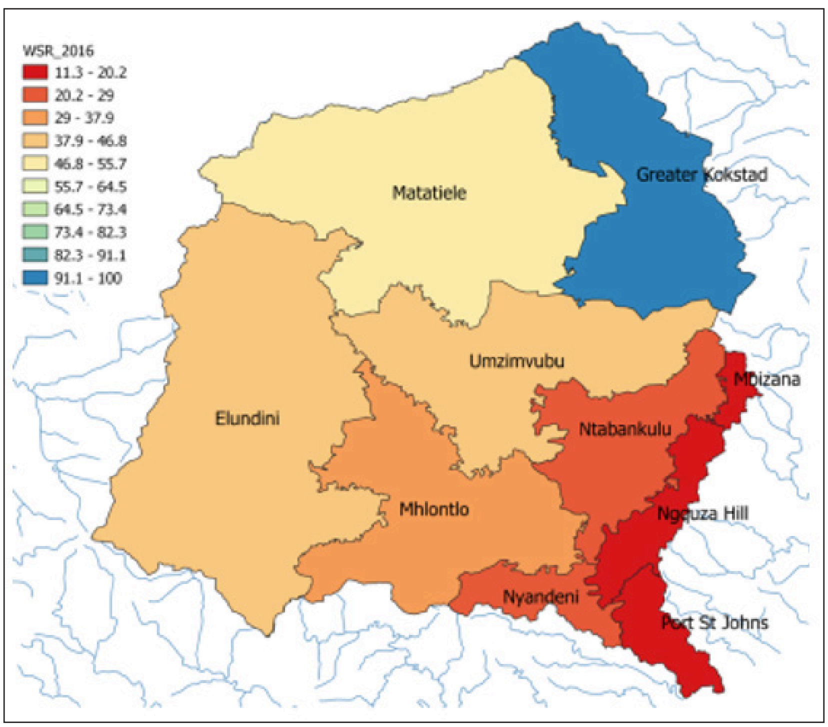

Figure 9. Access to drinking water is progressively worse as one moves downstream. Additional data indicates that these downstream communities are even more reliant on natural, unprotected water sources such as streams and springs.

3.2 **Regulation & Support**

Regulation and Support services refer to natural processes that (1) maintain the availability of water and fish (e.g., keeping water clean and flowing) and (2) provide protection against flooding and other hazards. Water resource management decisions often ignore the regulatory processes provided by the ecosystem, even replacing these "free" regulation services with built infrastructure, which can be costly. The Regulation and Support indicator comprises four sub-indicators: Sediment Regulation, Water Quality Regulation, Disease Regulation and Flood Regulation. **The Umzimvubu Catchment received a score of 45 for this service group, which shows critical health.** This score was weighted according to the relative importance given to the different services by stakeholders. Stakeholders placed greater weight (40%) on the Water Quality Regulation service, followed by the Sediment Regulation service (22%). Flood regulation (20%) and Disease Regulation (17%) were weighted as less important.

3.2.1 **Sediment Regulation**

The Sediment Regulation sub-indicator measures the ecosystem's ability to regulate the flow of sediment from terrestrial systems to streams and on to floodplains or downstream outlets. Excessive sediment, for example, from exacerbated erosion, can compromise the capacity of reservoirs to store water, or it can degrade water quality. In contrast, a lack of sediment distributed downstream generally deprives aquatic life and agricultural land of critical nutrients. **The Sediment Regulation sub-indicator in the Umzimvubu Catchment received a score of 18; which is a critically low score.**

This sub-indicator was calculated considering potential erosion risk in the different sub-catchments. The score obtained indicates that soil erosion is still very high, which, in turn, causes excessive flow of sediments into rivers and streams. It is worth noting that areas where there is extremely high erosion risk are in the upper and middle of Umzimvubu Catchment, and these are areas more naturally susceptible to erosion and where the natural land cover has been altered.

Figure 10: Exposed soil after removal of natural vegetation. *Photo credit: Sibusiso Ndaba (CSA)*

3.2.2 **Water Quality Regulation**

Water Quality Regulation refers to the ability of the ecosystem to regulate the concentrations of different water quality parameters in terms of potability for human consumption and other uses. Ecosystems “filter” many pollutants from water, but this capacity can be easily overcome by the volume of pollutants released by different human activities. **This sub-indicator obtained a score of 70, indicating a good ability to regulate water quality for human activities.** This result confirms that the Umzimvubu Catchment still has a very low urban population, and human activities that can pollute rivers and streams, such as industry and agriculture, are still growing in the region. Waste (e.g., litter, nappy disposal) released into rivers in rural areas, where there is no municipal waste collection, and certain agricultural practices (e.g., excessive application of fertilizers) reduce the water quality for human use. Stakeholders assigned this sub-indicator the highest weight among the Regulation & Support group, twice as high as any other sub-indicator, signaling its importance regardless of presently good health.

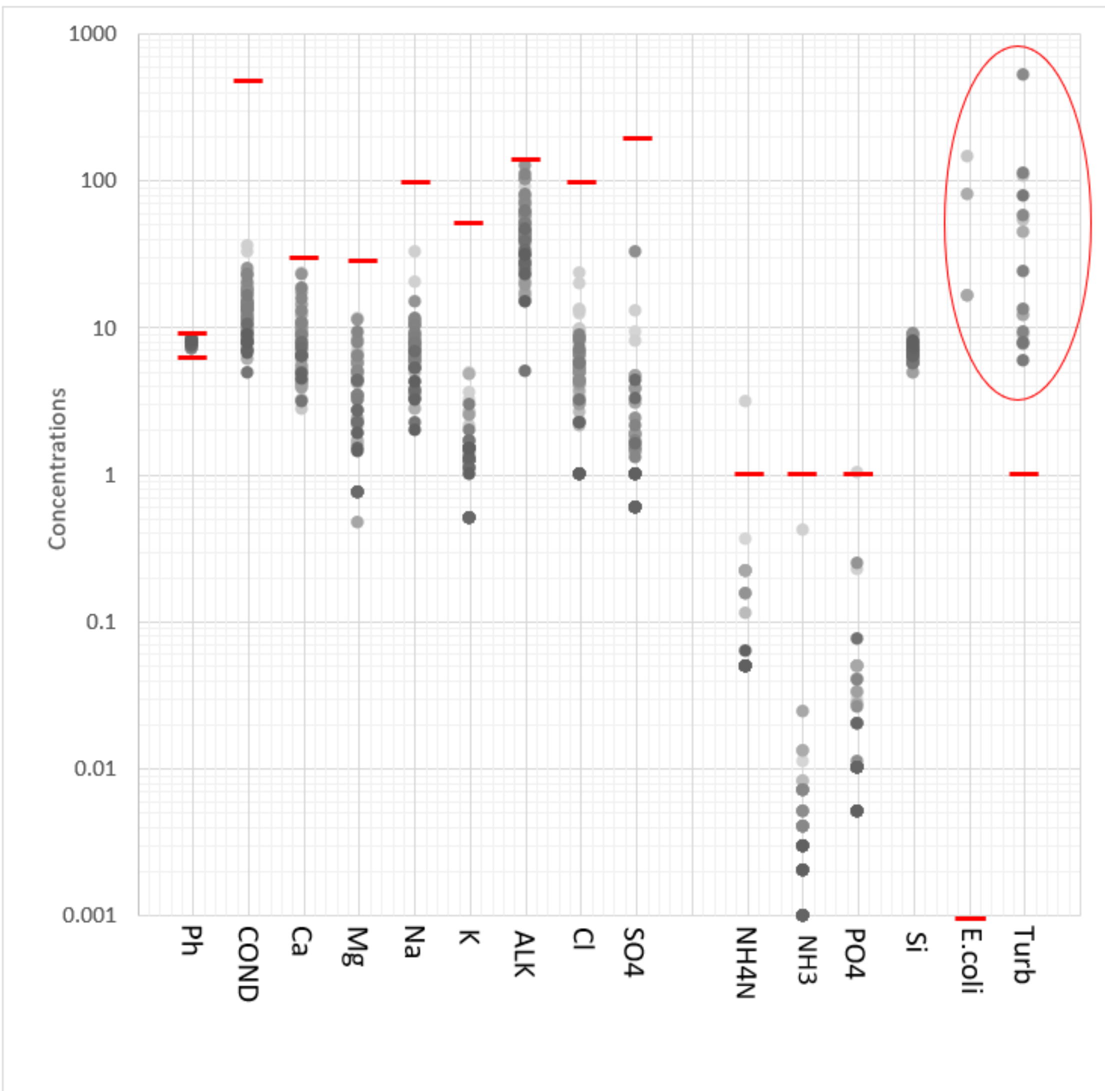

Figure 11: Water quality parameters and thresholds in the Mzintlava River near Kokstad monitoring station (T3H004Q01). E. coli and Turbidity stand out as having concentrations well above their regulatory thresholds (red lines).

3.2.3 **Disease Regulation**

The Disease Regulation sub-indicator measures the exposure of the population to water-associated diseases. Freshwater ecosystems play an important role in the transmission and containment of pathogens and vectors associated with various common diseases such as dengue, malaria and yellow fever. These diseases are one of the main causes of hospitalizations worldwide, and their risk to people increases with human changes to freshwater ecosystems (e.g., dam construction, pollution, riparian forest degradation). **The Umzimvubu Catchment received a score of 67 for Disease Regulation.** This data was collected using surveys to understand if there were any illness outbreaks that were caused by the local water. The results showed that 30 % of the participants indicated an outbreak in the local villages. These results highlight the impact of poor water access in this region, especially in rural areas, where there is an absence of piped water. Many families must use rivers and streams near their homes to meet basic needs, exposing themselves to the risk of contracting water borne diseases. It is worth noting that this result requires further review, since there is very limited data on the prevalence of water borne illnesses or diseases in this area.

3.2.4 **Flood Regulation**

The Flood Regulation sub-indicator measures the ecosystem's ability to reduce surface runoff volume by decreasing downstream peak flows and/or absorbing flood waters. The bare soils reduce water infiltration and increases floods during high rainfall periods, which, in turn, leads to the need for measures to control the excess water. Floods are one of the more expensive natural disasters, and intact forests and wetlands can help reduce the level of this hazard and keep people and property out of harm's way. **The Flood Regulation sub-indicator obtained a score of 43, indicating that the Umzimvubu Catchment's ability to control flood is relatively low.** In the case of the study region, whose coverage has been modified by transformative atypical species, this result reflects the reduced ability of the catchment to slow the timing of peak flow downstream and attenuate flood water. This is also a reflection of the condition of wetlands in the catchment, as there has been degradation to these ecosystems too. The predominance of natural floods affects human populations and agricultural activities located in the natural floodplains. Climate change could further exacerbate the present challenges to flooding in Umzimvubu Catchment in the future. This sub-indicator needs to be further investigated to ensure continued flood regulating services.

3.3 **Cultural**

Cultural Services refer to the non-material benefits people experience from aquatic ecosystems, such as their scenic beauty, recreational and cultural opportunities, or spiritual practices. These cultural services are linked to the benefits of physical, emotional, and mental health, as well as to opportunities for economic development (such as ecotourism). Freshwater ecosystems, in particular, are often associated with the cultural identity of a society. Stakeholders attributed a lower weight to this indicator (15%), which suggests that it currently has less importance in relation to Provisioning and Regulation and Support services. The Cultural indicator comprises two sub-indicators that represent experiences and values associated with freshwater ecosystems: Conservation of Cultural Heritage, and Recreation. **The Cultural Service indicator overall obtained a score of 14.** The stakeholders of the Umzimvubu Catchment gave much greater importance (84%) to the sub-indicator Conservation of Cultural Heritage than to the Recreation Service sub-indicator (16%). This is not surprising, given that cultural activities are generally linked directly to the natural environment and therefore more highly valued.

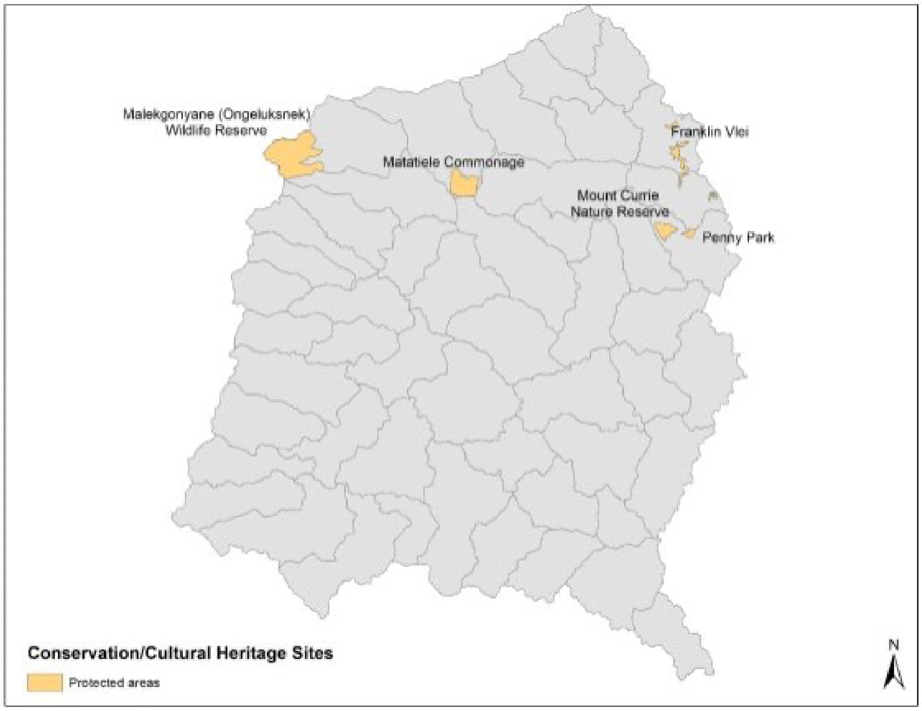

Figure 12: Conservation of Cultural Heritage in the Umzimvubu Catchment. Source: Critical Biodiversity Areas Statutory Reserves for the Eastern Cape (DWAF, 2007) and Important Bird Areas of Southern Africa (Barnes, 1998).

3.3.1 **Conservation of Cultural Heritage**

The Conservation of Cultural Heritage sub-indicator measures the degree to which freshwater ecosystems are preserved for their cultural importance, including biological and spiritual importance. These areas may relate to or reflect a society's cultural, religious and scientific values. **This sub-indicator received a score of 11.** This critically low value directly reflects the low number of protected areas (official and potential) within the Umzimvubu Catchment, where only 23,284 ha are protected (1.2% of the total area). These areas include Malekgonyane (Ongeluksnek) Wildlife Reserve, Mount Currie Nature Reserve, Penny Park, Franklin Vlei and Matatiele Commonage. Figure 11 shows their locations. It should be noted, however, that there is a need to include areas related to traditional communities and regions relevant to religious, spiritual and traditional practices, which may confer substantial additional protection on the natural landscape. However, spatial data on these practices were not available. It is suggested that a further assessment consider these regions to better represent this sub-indicator.

3.3.2 **Recreation**

The Recreation sub-indicator refers to water-related recreational activities such as fishing, hiking, boating or enjoying waterfront landscapes. These recreational activities provide important benefits for physical, emotional and mental health, but can also offer opportunities for economic development, especially if they attract tourism from people outside the catchment. **The Recreation sub-indicator obtained a score of 61, this reflects a moderate provision of recreational opportunities in the catchment.** The main activities noted as being important were swimming, boating, walking along streams, visiting wetlands, bird watching and fishing. Stakeholders also indicated the importance of municipal parks as a key option for visiting recreational sites and indicated that they would appreciate having more nature-based recreational options in the catchment. They also indicated that river, lakes and wetlands are important for cultural identity.

The score suggests that there is still space to increase the attractiveness of recreation and tourism activities in the catchment, especially due to the high degree of enthusiasm around nature-based recreational activities. The realization of this potential depends on increasing protected areas and access infrastructure in these areas.

 

Figure 13. The first stakeholder meeting conducted in Matatiele, South Africa in October 2020. *Photo credits: Fezile Matandela (CSA)*

4. GOVERNANCE & STAKEHOLDERS: INDICATOR AND SUB-INDICATOR RESULTS

The third component of the Freshwater Health Index, Governance and Stakeholders, assesses the structures and processes by which people make decisions related to water resources. In contrast to the indicators of the Ecosystem Vitality and Ecosystem Services components, where data are routinely collected and measurement methods are widely known, governance measurement is an emerging area without standardized approaches. Topics are also more subjective, which means that people's perceptions are a valid source of information. To gather information for this component, a survey was conducted with a group of key stakeholders whose work relates to the management of the Umzimvubu Catchment. The stakeholders represented government officials, researchers, the civilian community, and others with knowledge of governance issues in the Umzimvubu Catchment.

Combining the results of the survey, the Umzimvubu Catchment obtained a score of 51 for the Governance and Stakeholders component. Improving this score should be a priority for decision-makers in the Umzimvubu Catchment, particularly considering the expected increases in water demand and climate variability. The detailed assessments below provide information about where these improvements can be made. It is also important to note that the indicators and sub-indicators of this component were weighted by stakeholders, which revealed a preference for the Enabling Environment indicator (weight of 37%), followed by the Stakeholder Engagement indicator (weight of 32%). The weights reflect preference by stakeholders, highlighting what they deem as critical and needing to be prioritized.

4.1 Enabling Environment

The Enabling Environment indicator is related to the policies, regulations, market mechanisms and social norms that exist to help govern and manage water resources. Together, these attributes determine which rights and assets are protected within a river catchment, as well as their management in the face of conflicts. **Combining the five sub-indicators below, the Umzimvubu Catchment received a score of 44 for Enabling Environment.** This result suggests the need for significant improvements, which may involve national, regional and local actors. Among the five sub-indicators within the Enabling Environment indicator, stakeholders attributed the highest weight to the Water Resources Management sub-indicator (31%). The second highest value was attributed to the Rules for Resource Use (23%). Relatively similar values were given to the three remaining sub-indicators: Incentives and Regulations (18%), Technical

Capacity sub-indicator (13%) and Financial Capacity (14%). The highest evaluated function was the adequacy of the water policy coordination, rules for administrative boundaries, following Environmental Impact Assessment (EIA) processes, and honorary recognition programs. The lowest evaluated function was pertaining to whether the number of staff to fulfil necessary functions and level of investment in service delivery systems was adequate. This trend showed high consensus, meaning that people generally agree with this result.

4.1.1 Water Resource Management

The Water Resources Management sub-indicator assesses the degree to which institutions are responsible for performing functions such as coordination within the catchment, planning and development of infrastructure, mobilization of financial resources, and protection of ecosystems. Water Resources Management is a complex set of tasks, usually involving various public agencies and other stakeholders. Fragile coordination between these groups can lead to inefficient, unfair or ineffective results. **The Umzimvubu Catchment received a score of 46 for Water Resources Management.** Among the evaluated functions, the highest rated function was: “Policies and actions are in line with water resources improvement and management in the catchment.” The lowest-rated function, according to the survey, was: “Ecosystem’s conservation priorities are developed, and actions are implemented – such as protection of forest watersheds, wetlands, or developing an aquatic species biodiversity action plan.” Put another way, stakeholders perceived ecosystem conservation to be inadequately incorporated into water resources management in the catchment.

4.1.2 Rights to Resource Use

The Rights to Resource Use sub-indicator measures the clarity of rights to water and water-related resources. Clear and enforceable rules, whether formal or informal (e.g., community rights), are important for the efficient use of water resources and their equitable distribution throughout the catchment. **The Umzimvubu Catchment received a score of 51 for this sub-indicator.** This was also the highest score among the sub-indicators of Enabling Environment. While this sub-indicator received the highest score under this indicator, the score indicates that there is room for improvement. Among the rules evaluated, the highest score was for “Rules for allocating water among different sectors (e.g., municipal, industrial, agricultural) are clear and transparent.” This is important, since unclear rights regarding water use are often a source of conflict.

4.1.3 Incentives & Regulations

The Incentives and Regulations sub-indicator evaluates the availability of different management tools, such as impact assessments or financial incentives, which can be applied to reduce negative impact on water and related environmental resources. **The Umzimvubu Catchment received a score of 49 for Incentives and Regulations.** Among the incentives and regulations evaluated, stakeholders gave the highest ratings for “Environmental and social impact assessments for all major water projects, regardless of funding source, are carried out prior to decisions being taken” and the “Existence of honorary recognition programs”. This suggests that both formal and informal tools are in use in the catchment.

4.1.4 **Technical Capacity**

The Technical Capacity sub-indicator assesses the adequacy of the workforce, in terms of number, skill level and training opportunities, to fulfill technical functions related to the management of water resources. Even with sufficient financial capacity, the scarcity of technical skills, such as environmental engineering, can hinder the efficient and sustainable development of water resources. **The Technical Capacity sub-indicator for the Umzimvubu Catchment received a score of 38, which is the second lowest score among the five sub-indicators of Enabling Environment.** Stakeholders indicated that, among the four aspects of technical capacity analyzed (number of personnel, specialized personnel, training opportunities and professional certifications), the number of staff to fulfill necessary functions received the lowest score. This highlights the challenges in the backlogs (work waiting to be done) in certain agencies, poor services delivery and limited monitoring and evaluation in the catchment. It is important to note that, despite a perceived shortage of technical capacity within the catchment, there is the potential to tap into the technical resources (government, universities, etc.) provided by the membership of the UCP.

Figure 14. Virtual Stakeholder Meeting for the Umzimvubu Catchment.

4.1.5 **Financial Capacity**

The Financial Capacity sub-indicator measures the extent to which the necessary investments are made to support the development and protection of water resources. Public investment is necessary to ensure adequate funding for safeguarding, protecting and remediating ecosystems. **In the Umzimvubu Catchment, the Financial Capacity sub-indicator obtained a score of 30, the lowest score among the sub-indicators within Enabling Environment and the lowest among all sub-indicators of the Governance and Stakeholders component overall.** In general, the low score for this sub-indicator suggests that stakeholders believe that it is difficult to procure financial resources to make improvements in the catchment. Specifically, stakeholders indicated that the "Level of investment in service delivery systems is inadequate", thus this function received the lowest score. This reflected the limited financial resources for building and maintaining water distribution networks (i.e., piped supply) or household wells in the catchment.

Figure 15: Group discussions during the first stakeholder meeting conducted in Matatiele, South Africa in October 2020. *Photo credits: Fezile Matandela (CSA)*

4.2 **Stakeholder Engagement**

The Stakeholder Engagement indicator refers to all forms in which actors interact with each other within the catchment and the degree of transparency and accountability that characterizes these interactions. While stakeholder engagement takes place in different ways around the world, it is generally regarded as a key principle of good water governance. It ensures that the full range of concerns are considered before important decisions are made to avoid possible conflicts and ensure equitable distribution of benefits. The Stakeholder Engagement indicator is divided into two sub-indicators: Information Access and Engagement in Decision-Making Processes. **Stakeholder Engagement received a score of 57, which reflects that there is still space for improving this indicator.** Stakeholders attributed weights to the two sub-indicators within this indicator group: Information and Knowledge with a value of 39% and Engagement in Decision-Making Processes with a value of 61%.

4.2.1 **Information Access**

The Information Access sub-indicator assesses the availability and accessibility of data on water quantity and quality, resource management and development. Even in cases where data is routinely collected, if they are not available to those interested in research or analysis, decisions may be considered less transparent. Access to data also helps communities hold decision-makers accountable (for example, to determine whether a particular policy or project is delivering the expected results). **In the Umzimvubu Catchment, the Information Access sub-indicator received an overall score of 54.** This indicates that stakeholders are not satisfied with the level and availability of information about the catchment. In general, stakeholders indicated that the information does not meet expected quality standards, in terms of frequency, level of detail, and subjects of interest to stakeholders. This includes but is not limited to time series data on streamflow, water levels, or water quality for specific locations within the catchment.

4.2.2 **Engagement in Decision-Making Process**

The Engagement in Decision-Making Processes sub-indicator measures the extent of stakeholder participation in some aspects of decision-making processes and the degree to which they have a voice in the policy and planning cycle. While there are different levels of “adequate” commitment, greater participation is generally associated with better transfer of more specific and equitable information, plans and policies, transparency and accountability, and conflict reduction. **Engagement in Decision-Making Processes received a score of 60, which is the second highest score among all sub-indicators.** This score indicates that the actors recognize the role of existing participation platforms for different stakeholders to inform decision-making processes of the Umzimvubu Catchment. This score reflected the role that the UCP has played in bringing stakeholders together to discuss water resources management in an open and transparent way.

4.3 **Effectiveness**

The Effectiveness indicator evaluates the results of water-related policies and investment decisions. In other words, it is meant to measure whether the governance system is achieving what it was intended to do. Around the world, there is often a gap between policy and practice, between what is expected based on a complex decision and what actually happens. Thus, the effectiveness sub-indicators try to assess whether decisions are having the intended effects. **The Umzimvubu Catchment obtained a score of 49 for this indicator, suggesting a disconnect between policy and practice.** Among the three Effectiveness sub-indicators, stakeholders attached greater importance to the Enforcement and Compliance sub-indicator (44%), followed by the Distribution of Benefits from Ecosystem Services (39%), followed by the Water-Related Conflict indicator (17%).

4.3.1 **Enforcement & Compliance**

The Enforcement and Compliance sub-indicator measures the degree to which laws are respected and agreements are executed. The "compliance gap" may reflect insufficient regulatory capacity or lack of accountability, which weakens the effectiveness of laws and policies. **The Umzimvubu Catchment received a score of 42 for the Enforcement and Compliance sub-indicator – the stakeholders surveyed show significant concern about the effectiveness of laws and policies.** Among the execution of the five types of guidelines analyzed (for water abstractions, groundwater abstractions, flow, water quality and land-use guidelines), stakeholders indicated that surface and groundwater abstraction guidelines are not well enforced in the catchment.

4.3.2 **Distribution of Benefits**

The Distribution of Benefits from Ecosystem Services sub-indicator refers to the impacts of decisions on the management of water resources, with special attention to the different segments of society: rural, urban, migrants without local work registration, and those employed in resource-dependent sectors, such as fishermen. Water-related ecosystem services are, by nature, unequally distributed in a catchment, so measures (such as the development of reservoirs and water distribution networks) often must be taken to ensure that resources are allocated equally. **The Umzimvubu Catchment obtained a score of 55 for this sub-indicator.** This score reflected the need to improve the distribution of ecosystem services across the catchment. The responses from the survey showed the lowest score for "All districts and actors share in the benefits from ecosystem services."

4.3.3 **Water-related Conflict**

The Water-Related Conflict sub-indicator reflects tensions between the parties when there is competition for scarce resources such as water. Tension results in legal battles or can prevent the resolution of conflicts and, therefore, can delay or weaken decisions within the catchment. The FHI is restricted to the evaluation of disputes over water allocation, access, pollution, diversion, and infrastructure development. **In the Umzimvubu Catchment, the Water-Related Conflict sub-indicator received a score of 53. Stakeholders currently view the presence of water-related conflict as the least worrisome theme in water.** In other words, more efficient resolution of water-related conflicts is not a major priority needing immediate improvement. Among the five types of conflicts analyzed (overlapping jurisdictions, allocation of water rights, conflicts of access to water, positioning of infrastructure, and conflicts over water quality and other negative downstream impacts), the most frequent, according to stakeholders, are those related to water rights allocation.

4.4 Vision & Adaptive Governance

The Vision and Adaptive Governance sub-indicator measures the ability to gather and interpret information and then use this information to establish policies, develop plans for the catchment, and adapt to changing circumstances. Effective management of water resources requires flexible and integrated forms of governance to address often changing conditions and uncertainty associated with climate change and other emerging challenges. Therefore, Strategic Planning and Adaptive Management is an important aspect and is one of the sub-indicators here, along with Monitoring Mechanisms, which allow updating and adapting management actions as circumstances change. **The Umzimvubu Catchment received an overall score of 58 for Vision and Adaptive Governance, the highest score among the indicators of the Governance and Stakeholders component.** Stakeholders attributed similar weights to the two sub-indicators: 39% for Monitoring Mechanisms and 61% for Strategic Planning and Adaptive Management.

4.4.1 Monitoring Mechanisms

The Monitoring Mechanisms sub-indicator refers to the quality and use of physical, chemical and biological monitoring of water resources in the catchment to guide planning policies and processes. Ideally, decisions on water resource management are based on robust data and information, but this requires collecting this information (which incurs costs) and use of that information by decision-makers. **The Umzimvubu Catchment obtained a score of 61 for this sub-indicator, the highest score among the sub-indicators of the Governance and Stakeholders component.** All four variables analyzed (quantity, quality, biological, and access to monitoring) were given relatively high scores, and stakeholders also indicated that this theme is not of critical importance currently.

4.4.2 Strategic Planning & Adaptive Management

The Strategic Planning and Adaptive Management sub-indicator is concerned with the extent to which strategic planning (i.e., the accounting of land and water use and infrastructure development) takes place within the catchment. Having comprehensive plans, with well-defined objectives and long-term resource development priorities, can help establish a vision to sustainably meet water needs. More importantly, perhaps, plans should be adjusted as circumstances change, when new information is made available, or when unforeseen events occur. **In the Umzimvubu Catchment, the Strategic Planning and Adaptive Management sub-indicator received a score of 56.** The three elements evaluated for this sub-indicator are: establishment of shared vision for the catchment to guide future development, use of strategic planning mechanisms, and use of an adaptive management structure. Stakeholders gave the lowest rating to the use of adaptive management, highlighting an area that could use improvement, particularly in light of climate change.

A STREAM IN THE CATCHMENT © CI/CAROLINE ROSE

5. CONCLUSION

The Umzimvubu Catchment FHI assessment demonstrated that the ecosystem service delivery is under stress, mainly due to poor water supply reliability and cultural service delivery. These results show the need for enhancing the supply of benefits that people in the catchment need and strengthening the institutional decision-making for water resources management. One of the factors that the results confront is the current and future role of spring rehabilitation and protection work to alleviate the identified water access challenges in the catchment. Collaborative work between ANDM/MLM and CSA to integrate springs with existing municipal infrastructure can help address this, matching labor from the villages with hard infrastructure from the municipality.

The FHI assessment provides a process to deeper engage more deeply with stakeholders' practices and their commitment to improved water resources management. It provides a broad understanding of the status quo of freshwater systems that managers and decision-makers can use to further investigate some of the challenges identified in this assessment. This process can be done through extensive modelling, mapping and ground-truthing of these variables to further justify and inform the development of a shared vision for the catchment. The shared vision should reflect the findings from this report, address the data gaps highlighted and suggest plans to improve poor-performing indicators. This plan should be spatially explicit and align with the work of the stakeholders in the Umzimvubu Catchment Partnership.

The index provides a guide for future investment in freshwater systems in the catchment and has the potential to inform future priorities. These priorities should be captured in the shared vision and catchment plan and done in consultation with all stakeholders. Some of the suggestions that were highlighted by stakeholders on improving the governance component:

Technical capacity	• To expand collaboration outside Umzimvubu, e.g., private sector, local businesses, grey infrastructure to improve local capacity. • To promote cross catchment learning opportunities to share lessons and raise the profile of catchment management across different levels of government.
Financial capacity	• Build capacity around understanding linkages of ecosystem services and people to fundraise for conservation of watersheds, possibly through billing rates and utilities. • To assess whether the available funding is being used appropriately. • The conservation sector needs to improve on making a business case for water security to get more investment.
Enforcement and Compliance	• To encourage the use of Conservation Agreements and develop a tool to ensure levels of enforcement and compliance at the community level. • Provide innovative incentives models to encourage compliance. • Develop forums or associations that will play a role in enforcement that will lead to social pressure to promote compliance • Encourage people of influence, such as ward councillors and traditional leaders, to assist in compliance through their bylaws. • Promote an enabling environment for farmers who want to comply as they are faced with many challenges.

Finally, there were several data deficiencies that were highlighted through the assessment process. It is clear that many catchment residents are dependent on harvested products in the catchment (fish, reeds, thatch, etc.); this dependency should be better understood so that these resources can be managed sustainably. Similarly, there is limited data on the prevalence of waterborne illnesses and diseases in the catchment, and so the current estimates may be conservative. And regarding Conservation of Cultural Heritage, it was acknowledged that areas related to traditional communities, and regions dedicated to religious, spiritual and traditional practices, all may serve to protect the natural landscape, but without spatial data on these practices, they were not considered in the estimate (which was based on formally designated protected areas).

APPENDIX: METHODOLOGY FOR INDICATOR CALCULATIONS

The full documentation of the methods for the Freshwater Health Index (FHI) is available in the FHI User Manual, which can be accessed through the website (freshwaterhealthindex.org). The following are details of the methods and data used for the evaluation of the Umzimvubu Catchment in South Africa. It is important to highlight that all sub-indicators were aggregated at the level of the indicators, which, in turn, were aggregated at the component level. The aggregation of sub-indicators and indicators of the Ecosystem Vitality component was done by geometric mean, while the sub-indicators and indicators of the Ecosystem Services and Governance and Stakeholders components were aggregated by weighted geometric mean, considering the relative importance (weight) given by stakeholders to each of the indicators and sub-indicators. It is important to note that a geometric mean often delivers values that differ from the more commonly calculated arithmetic mean, because it is less influenced by outliers (a single exceptionally low or high score in a set).

ECOSYSTEM VITALITY

Deviation from Natural Flow Regime

We used WRSM2000 (Pitman) rainfall-runoff hydrological model of the Umzimvubu Catchment system to determine deviation from natural flow regime. We compared the modeled regulated flow against modeled unregulated flow using the Amended Annual Proportion of Flow Deviation indicator (AAPFD) (Gehrke et al., 1995; Gippel et al., 2011). This was for the period of 1965 to 2009. The AAPFD gives a score, whereby the higher the number, the greater the alteration. This score was transformed and normalized to a 0-100 range, with 100 being no deviation from the natural flow regime. The basin-wide deviation from natural flow regime score was the weighted (by mean annual discharge) arithmetic mean of the scores from five locations: (1) T3H009 the Mooi river at Maclear; (2) T3H006 the Tsitsa River at Xonkonxa; (3) T3H005 the Tina River at Mahlungulu; (4) T3H008 the Umzimvubu River at Komdraai; and T3H004 the Mzimtlava River at Slang Fountein.

Water Quality Index

The Water Quality Index measures how much water quality parameters differ from the values needed for the functioning of aquatic ecosystems and is calculated using the modified CCMW method (Canadian Council of Environment Ministries, 2001). This method incorporates three elements: 1) Scale: the number of variables that do not meet water quality limits; 2) Frequency - the number of times quality limits are not reached; and 3) Amplitude - to what extent objectives are not achieved. The index produced is a number between 0 (worst water quality) and 100 (best water quality) that is used as a score for the FHI.


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Data from 15 parameters (pH, electrical conductivity, calcium, magnesium, sodium, potassium, calcium carbonate, chloride, sulfate, nitrate, nitrite, ammonia nitrogen, ammonia, phosphate, turbidity, *E. coli* coliforms) measured in 6 monitoring stations. This was for the period of 2017 to 2019, and data was provided by the Department of Water and Sanitation. It is worth mentioning that the map that shows the location of the monitoring stations used for the 'determination of water resource classes and Resource quality objectives for the water Resources in the Umzimvubu catchment Status Quo report' (DWS 2017). Thus, the FHI analysis, same stations were considered, and recent datasets were.

The thresholds used for the parameters necessary to ensure the conservation of aquatic ecosystems were obtained mainly from the South African Water Quality Guidelines (DWS, 1996).

The final score of the catchment was a geometric mean between the indexes obtained for each monitored station, using the length of the drainage network (according to the Hydrocatchment database, Lehner and Grill, 2013) above each monitoring station as weight.

Bank Modification

Bank Modification was evaluated using the loss of riparian vegetation as a proxy for changes in the riverbanks. Land use within a 100-m riparian zone was extracted from the South African National Land-Cover map (SANLC) generated from the Sentinel 2 satellite imagery for the year 2018. A score was assigned for each class of land use, ranging from 0 – no modification to 1 - complete modification, such as rectification of rivers and creation of artificial channels. Specifically, for the Umzimvubu Catchment, the following scores were used: 0 for near natural riparian corridor; 0.25 for some modification (including agricultural use); 0.5 modifications are visible; 0.75 large sections of the channel are clearly modified and 1 for fully modified channels. Scores were assigned for all the classes and were verified by visual inspection using high-definition satellite images of Google Earth (Google Earth, 2020). In general, riparian areas showed some level of degraded in some parts but, overall, the modification in riparian zones is low. The study by Mararakanye and Le Roux in 2012 on the gully location map at a national scale for South Africa, provided and additional layer to assess the changes in the riparian zone caused by gully erosion, which is a major driver of change in the landscape. These gully erosion areas aligned with the determined modified areas using the land cover map.

Flow Connectivity

Flow Connectivity was evaluated using the Dendritic Connectivity Index (DCI). It was assumed that "passbility", that is the ability of a fish to cross a dam in any direction, was one in river channels which were considered 'critical corridors for movement of fish species' (CSIR, 2011) and zero for where no information was found on the design of the dams. The DCI, therefore, was calculated as a function of the length of the channel fragments compared to the total length of the drainage network. For the analysis, we used: (1) map of the drainage network provided by the National freshwater Ecosystem Priority Areas (Nfepa) (CSIR, 2011), more specifically the shapefile 'Nfepa rivers', and (2) shapefile of dam locations (kindly shared by the Department of Water and Sanitation-East London Office). Given that the Umzimvubu Catchment open out to the Indian Ocean, the DCI was calculated by weighting both, the potadromous and diadromous fish species.

Land Cover Naturalness

The Land cover Naturalness was evaluated using the land use map produced South African National Land-Cover map (SANLC) generated from the Sentinel 2 satellite imagery for the year 2018 (DEFF, 2018). The different classes of land use on the map received scores ranging from 0 to 100, according to the following criteria: 100 for forest, savannah, natural pasture, shrubby vegetation, swamp, water, 60 for agricultural areas with shrubs, 50 for irrigated agricultural areas, 0 for urban use. Sub-classifications are suggested based on three factors:

- *Management of the water cycle:* manually altering the flow and/or use of water to maintain a particular land-use type
- *Pollution:* chemical and physical pollutants entering the local water cycle due to cultural practices, such as fertilizer and pesticide use, and increased soil runoff from croplands as well as urban runoff and point-source wastewater loads from urban and industrial lands
- *Vegetation characteristics:* degree of native vegetation and permanence of vegetative cover

The naturalness was calculated in relation to a pixel of 20m. The score for each of the sub-catchments was the mean value calculated using the zonal statistic. The final score for the entire Umzimvubu Catchment was calculated using geometric mean using the values for each sub-catchment.

Species of Interest

Species of Interest is the degree of threat to aquatic species (fish, amphibians, crustaceans, mollusks, insects and plants). As there were no continuous species monitoring data for the Umzimvubu Catchment, this sub-indicator represents only the proportion of species with some kind of threat in relation to the total diversity of species already observed. This proportion is weighted according to the IUCN classification for each species, that is, critically threatened, threatened, vulnerable and almost threatened. For the Umzimvubu Catchment, data from the species of interest were obtained from the IUCN Red List (2021) and the Freshwater Biodiversity Information System (FBIS) with spatial information for amphibians, reptiles, crustaceans, mollusks, insects, birds, and fish.

Invasive Species

This sub-indicator is the predominance of invasive species in the catchment. As there is no continuous monitoring data of invasive species for the Umzimvubu Catchment, the calculation used the proportion of invasion of woody alien plant species (Acacia dealbata is one of the main drivers of change in this region) to the total catchments area. There was no invasive alien plant map for this region, therefore the sentinel-2 product was used to identify and map IAP through supervised classification. Known ground points were used to train and ground truth the output, though there is still space to further develop this product. The map is an indication of the extent of woody alien plant invasion, although there is still a need to also consider the impact that these plants have of freshwater systems. To convert this map data into an indicator, we first calculated the percentage of IAP coverage in each sub-catchment. We then used the Ecosystem Services Indicator (Shaad et al., 2022) method to calculate an index score, using a threshold of "minor invasion" (<2%) to measure good health (Van Wilgen et al., 2018). The ESI approach considers the number of sub-catchments that exceed the threshold, as well as the magnitude of each excursion, in compiling a score from 0-100.

ECOSYSTEM SERVICES

All Ecosystem Services sub-indicators were calculated using the same general approach, the Ecosystem Services Indicator (ESI) method documented in Shaad et al. (2022), which measures where within the catchment demand for a service is unmet, how frequently this occurs, and the magnitude of unmet demand. Input data vary according to the service, but at a minimum, require a map with discrete spatial units (e.g., sub-catchments) and a threshold, or expected level to satisfy demand.

Water Supply Reliability Relative to Demand

This indicator is designed to give a measure of the ability to meet water demand from various sectors, with respect to total water available. In this case, however, we focused exclusively on household access to safe drinking water, given its importance to many stakeholders, its relevance in the regional context, and the availability of a robust dataset covering the catchment. Using data from the South Africa's Community Survey 2016 (http://cs2016.statssa.gov.za), we evaluated access to safe drinking water at the local municipality (ADM3) level in the catchment. Using the ESI method and a threshold based on the 2016 national average of 82.5% access, we calculated an indicator score for each local municipality that reflects how far above or below the national average each local municipality was.

Biomass for Consumption

There was limited information on assessing biomass for consumption related to freshwater systems in this catchment. This indicator seeks to understand the yield of fisheries, wild food, fiber, and other materials from freshwater systems for human use. However, in the absence of existing data, a stakeholder survey was administered to understand the use of biomass. A total of 123 participants completed an online survey, these individuals are from or reside in the upper, middle, or lower catchment. The main categories for biomass use were medicinal plants, fishing, hunting, harvesting of thatch grass (ingca), harvesting of river beads (ubuchwabase), Reed harvesting (iingcongolo/umhlanga) and clay for pottery. Participants also indicated if they were using the harvested material for supporting their livelihoods, and if there are any rules for harvesting of these resources. There is an apparent need to investigate this trend and pursue additional studies that can complement these findings.

Sediment Regulation

This indicator seeks to identify areas affected, the frequency and degree of change in sediment deposition and erosion thresholds in a catchment. Sediment regulation indicator assesses the loss in reservoir storage capacity, loss in floodplain deposits and change in delta deposition/erosion. The indicator was calculated using the potential erosion risk generated through the RUSLE model (Le Roux et al., 2008). This modeling was conducted by Le Roux et al. at a national scale to account for the potential and actual water erosion risk. The Revised Universal Soil Loss Equation model was adopted for this study as a robust way to estimate sheet and rill erosion by runoff from slopes under various land use. In addition, the model considers climate, soil profile, relief, vegetation, and land management practices in estimating this risk.

The threshold value for potential erosion rate was recently estimated for the sub-Saharan region for 2012 in a global assessment (Borrelli et al., 2017). It was considered more useful to use a regional threshold than to use the generic tolerable rate of 10 tonnes per hectare, as the Borrelli et al. (2017) considers the different degrees of agricultural practices applied by different countries, which may reflect the level of development of a given region.

Water Quality Regulation

The Water Quality Regulation was evaluated by the same method of the Water Quality Index, described in the Ecosystem Vitality component. The difference is that the thresholds for this sub-indicator are less restrictive. For the analysis, the same data used to calculate the Water Quality Index in the Vitality component were included. We considered the acceptable limits necessary to ensure the potability of water determined by national legislation (South African Water Quality Guidelines 1996), which establishes limits for the quality of water intended for human consumption. The legislation provided the limits for pH, electrical conductivity, temperature, nitrate, ammonium, total phosphorus, sulfate, iron, manganese and fecal coliforms turbidity, nitrite, total dissolved solids, oxygen saturation and total coliforms.

Disease Regulation

The Disease Regulation Indicator was evaluated using stakeholder perceptions about the prevalence of water related illnesses in local villages. There is limited data available on recorded water related diseases in this region. Data for this indicator was sourced from a study by Environmental Rural Solutions (ERS) and Dartmouth College, undertaken in 2021. This study was to understand the current practices and perceptions related to livestock, water, and biomass. This study focused in six local villages, namely Moshoeshoe, Sibi, Makhoba, Mafube, Mzongwana and Nkosana, with 300 participants. The study showed that 30% of the respondents indicated that they have experienced an illness outbreak in their village that was caused by the local water source.

Through this study it was possible to understand which villages in the Umzimvubu Catchment have experienced water related disease outbreaks, which could be used as indication of the water quality issues in these areas. These villages are a subset of the total catchment area, thus there is a need to better understand the water related illnesses that dominate this catchment through in-depth studies. To further investigate which type of disease, where in the catchment is it prevalent, what are the acceptable thresholds and subsequently develop strategies to address their impacts. Literature shows that the cholera epidemic in 2000-2001 which spread from Northern KwaZulu Natal to the Eastern Cape was one of the well documented water related disease outbreak recorded. This outbreak raised awareness on access, functionality, and quality of water resources in these provinces. It also highlighted the lack of piped infrastructure, and the irregular water supply in infrastructure that exists, resulting in many households using traditional water sources (collecting from rivers and springs) which were often contaminated (SAHR, 2016).

Flood Regulation

Flood Regulation was evaluated by identifying the occurrence, frequency and amplitude of floods. That is, the calculation was not based on specific data on the number of people affected by flooding—which would be ideal—but rather, based on the flood events. We calculated the Flood Regulation indicator using the six gauged stations along Umzimvubu River with defined flood levels (T3H004 - Mzintlava River at Slang Fontein; T3H005 - Tina River at Mahlungulu; T3H006 - Tsitsa River at Xonkonxa; T3H007 - Mzimvubu River at Ku-Makhola; T3H008 - Mzimvubu River at Kromdraai; T3H009 - Mooi River at Maclear), using the gauging stations water level time series from 2010-2020. The indicator was calculated using 1) the presence of flooding using the pre-defined flood levels, and 2) the magnitude of the floods based on their exceedance of the levels.

Conservation and Cultural Heritage

This sub-indicator was evaluated by determining the percentage of the length of the drainage network within protected areas. The goal is to have at least 17% of the drainage network within protected areas. This percentage is the limit set by the Aichi Goal for Biological Diversity. The length of rivers and streams within and at the limit of the protected areas system were obtained from the river network data set. These were compared with the total length of the Umzimvubu Catchment drainage network, using the following formula:

$$PoR = \frac{0.5 * BL + IL}{RL} * 100$$

PoR is the percent of river length protected; BL, the length of rivers bordering protected areas; IL the length of rivers within protected areas; and RL is the total length of rivers within the Umzimvubu catchment. We used the global target minimum (17%) of wetlands and waterways, following the Convention on Biological Diversity's Aichi Biodiversity Target 11. The value is then scaled using an asymptotic function:

$$CS = 1.17 * \frac{PoR}{PoR + 17}$$

Additionally, protected areas and areas that have high potential to be designated as protection areas were also included. These areas may be formally or informally protected, such as nature reserves, parks, important birdlife areas. These areas include Malekgonyane Wildlife and Matatiele Commonage. Even if they are not under any type of official protection currently, the inclusion of the potential protected areas was appropriate because they are areas identified with values that are worth preserving.

Recreation

For the calculation of this sub-indicator, data on continuous monitoring of the number of visitors in waterfalls, rivers, reservoirs, among other watercourses, in protected areas or not is ideal. As these data were not found for the study catchment, the potential for recreation was quantified through surveys. A total of 123 participants filled out a survey to understand the water related recreational activities that exist in the catchment. The sub-indicator score was derived directly from a survey question asking participants to rate the quality of outdoor water-related recreation using a 1-10 scale. The average was multiplied by 10 to arrive at a final score. The key activities were indicated to be swimming, fishing, boating, taking walks along streams, and visiting wetlands.

GOVERNANCE & STAKEHOLDERS

The Governance and Stakeholders indicators were determined by applying a perception survey with 50 questions, using a 5-point scale. The perception survey was administered online after the second stakeholder engagement. In total, 14 actors participated, representing sectors of government, civil society, academy, industries and NGOs, with knowledge on governance issues in the Umzimvubu Catchment. The scores of each question were then aggregated into average values within modules, where each module was related to each sub-indicator and included 3 to 6 questions. The mean values were then normalized to a scale from 0 to 100.

WEIGHTING

The assessment of the relative priority that stakeholders give to indicators and sub-indicators of Ecosystem Services and Governance and Stakeholders components was carried out using a method for measuring multi-attribute utility (Edwards and Barron 1994). This method was administered online after the second stakeholder engagement workshop, where participants were able to perform a series of paired comparations and then evaluate the strength of their preferences.

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